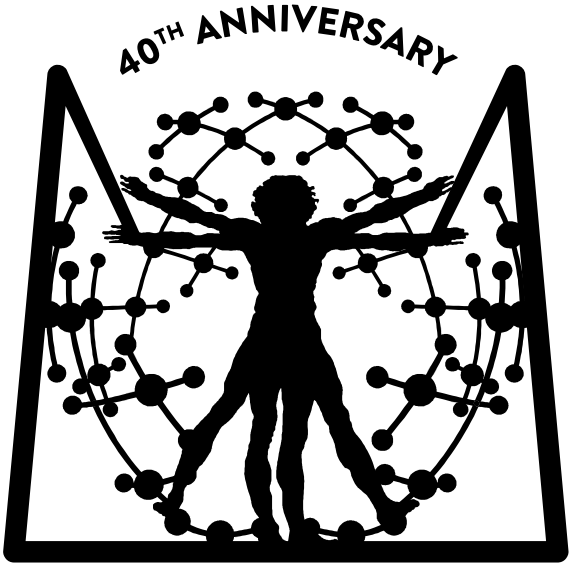
Teaching Geometry and Surfaces Evaluation Through Graphic Representation and Dynamic Paper Models



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(Executive Chairman)

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TEACHING GEOMETRY AND SURFACES EVALUATION THROUGH GRAPHIC REPRESENTATION AND DYNAMIC PAPER MODELS

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The use of physical models has always been an important point of touch between theories and practice for technical professions like that of architect and engineer. Nowadays, thanks to software programs, the two-dimensional representation of three-dimensional objects has been remarkably developed, but it is still important to provide students of architecture with some practical experiences, to make them interact with the tangible part of the architectural information processing course, which professionals develop through all the design process. Thus, we looked for a medium suitable to create simple three-dimensional models not only observable, but tangible: this stimulates in students a close connection between thought and action.
We present a teaching experience between mathematics and architecture: it is an example of lesson for first year students of the bachelor program in Architecture, proposing a geometric investigation of ruled surfaces. To make the cognitive process more interactive, we produced teaching aids (tangible models, graphic tablets) that help students to visualize geometrical-analytical investigations and enhance their spatial prefiguration and critical form-reading skills, three-dimensional thinking and geometrical reading of shapes, in particular of ruled surfaces.
This educational activity involves the presence of a mathematician and an architect, showing some mathematical topics as necessary tools in an architect's professional toolbox, to foster geometric communication, in the spirit of what Guarino Guarini said: «Architecture depends on Geometry». We tested it into two courses: Calculus, and Architectural Drawing and Survey Laboratory, verifying the specificity of the two disciplinary languages.
Students are invited to manipulate origami inspired paper models of two different roofing systems, a pyramid and a cloister vault having the same height, while the two teachers describe them geometrically as ruled developable surfaces, generated by two intersecting cylinders. Students work in teams and formulate conjectures to solve a concrete problem: estimate a restoration of a roofing system. First, they must predict how bigger in percentage are the developed surfaces of the pyramid and of the cloister with respect to their common orthographic projection (most popular values are 30% and 50%, respectively). Then, using the graphic tablet, or its prints, (see Fig. 1), students are guided to the actual surfaces evaluation with increasingly sophisticated mathematical tools: from Pythagorean Theorem for the pyramid, to the integral calculus for the cloister vault. For this last calculation, the dynamism of the cloister model is used to develop the surface and to perceive visually that each cloister face has a sine wave as a profile. The calculation leads to percentages very different from those conjectured by students: 50% in the pyramid case and 100% in the cloister case and offers interesting educational hints for discussion.
Furthermore, this experience stimulates the critical reading and evaluation of the drawn geometry (ruled surfaces, projections, developments).
Students involved in this experience participate very actively, consolidate topics taught within the Architectural Drawing and Survey Laboratory and understand the introduction of the integral calculus within the course of Calculus; moreover, the questionnaires at the end of the courses show that this experience is particularly welcome.

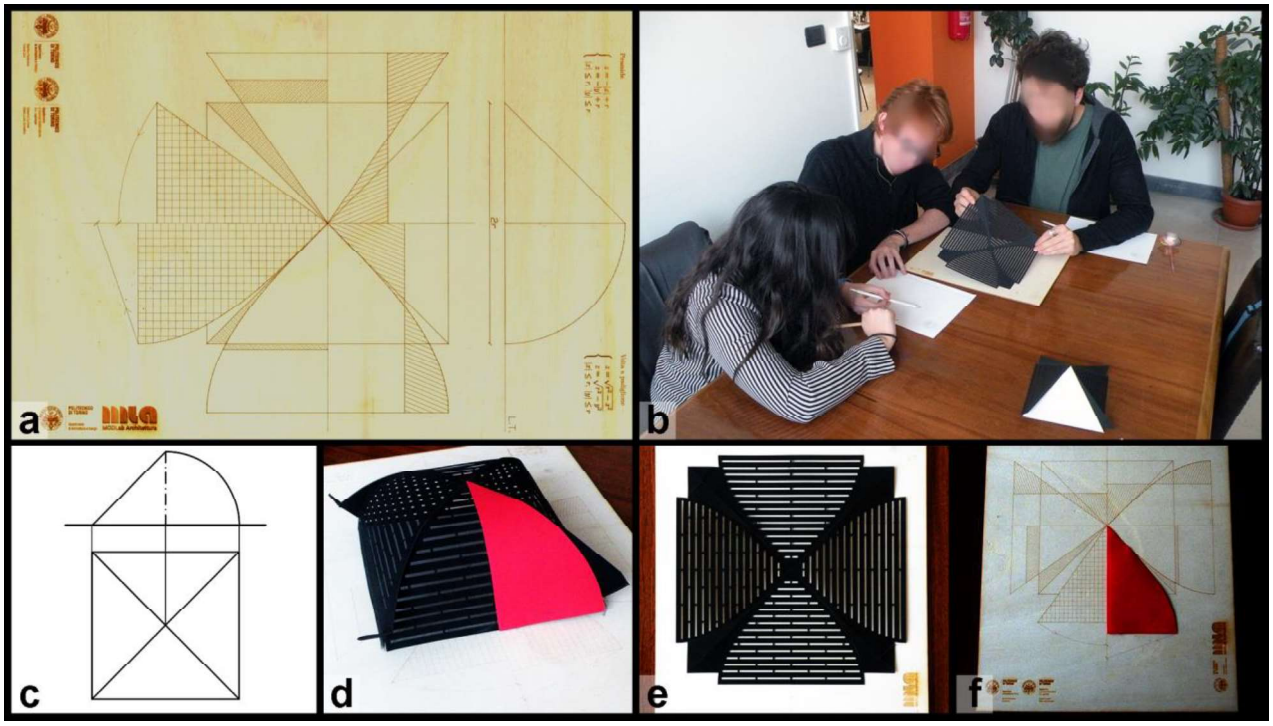

Figure 1: **a)** Plywood Graphic Tablet (G.T.) representing orthographic projection and unrolled surfaces of a square-based pyramid with height equal to half of the base side, and a cloister vault, generated by two intersecting semicircular cylinders of radius equal to the pyramid height. **b)** Students using our G.T.: a wooden (static) support animated by a (dynamic) paper model; **c)** Orthographic projection **d)** Folded cloister vault paper model with highlighted half face that you can see visualized on the G.T. **e)** Unfolded cloister vault model superimposed on the G.T **f)** G.T. with highlighted developed half face to evaluate it.

Keywords: Design Analysis; Descriptive Geometry; Calculus; Developable Surfaces; Spatial Thinking; Teaching Tools